How Much Does R&D Decision Depend on Firm, Industry, Group and its Interactions?

K.S.Sujit[*] and Badshah Mukherjee[**]

Abstract

In the recent year, technological progress through research and development (R&D) has been widely recognized as a key factor contributing to economic growth and competitiveness of the economy. In the traditional industrial organization (IO) literature R&D activities was considered to be an important conduct variable that can affect performance of the industry. Industrial organization (IO) literature stresses that the R&D behaviour is linked to industry structure and has the ability to create barriers to entry.

On the other hand subsequent studies have stressed on the strategic groups within an industry as the main driving force behind the R&D behaviour of firms. However, the resource based view stresses on the internal capability of the firm as the main driving force. They also emphasized that the behaviour of the firm is path dependent. This study is an attempt to measure the effects of industry, group, and firm on R&D behaviour of the firm and their interaction. The study uses both continuous and categorical variables in an ANCOVA setting. The sample consists of data about Indian companies across 29 industries during 1995-2003. The findings show that though the effects of the industry and the firm are important, the most significant contributor is the effect of the interaction between the groups and the industry.

Acknowledgement: We wish to thank Prof A. K. Rao for the comments and suggestions made during the preparation of this manuscript.

[*] *Assistant Professor, Department of Economics, Faculty of Business and Economics, Alemaya University, Alemaya, Dire Dawa, Post Box 252. Ethiopia. Phone: 00251-5-111399, Fax: 00251-5-114008*
E-mail: kssujit@gmail.com

[**] *Research Fellow, The ICFAI Institute for Management Teachers, ICFAI University,3rd, Floor, Astral Heights, Road No. 1, Banjara Hills, Hyderabad , Andhra Pradesh, India. P.O. – 500034, Tel: 91 40 23430469,*

Fax: 91 40 23430468, E-mail:badshahmukherjee@gmail.com

1. Introduction:

In the recent years, technological progress through research and development (R&D) has been widely recognized as a key factor contributing to economic growth and competitiveness. With the introduction of product patents in most countries, the role of R&D is going to be more important in the years to come. At the macro level the role of R&D can be viewed as a basis of competitive advantage, which is the basis of international trade. At the firm level, the objective is to change the market conditions in its favour under which it operates. This plays an important part of the competitive strategy of the firm. It may also help the firms to grow and diversify (Hay and Morris, 1991).

R&D activities are risky and hence the decision to fund is crucial. This is why R&D expenditure as an investment decision has drawn considerable attention in the literature of industrial organization. The resource for funding R&D projects is linked to the structure of the market. The literature on Industrial Organization concentrates on two contradicting views by Arrow (1962) and Schumpter (1965). Both the studies use the structure conduct performance (SCP) perspective. The structure determines the behaviour of the firm and ultimately the performance of the industry. Here, behaviour includes R&D activities, which is always featured as an important conduct variable. Arrow (1962) is of the view that the incentive to go for R&D activities is more in the competitive market structure than the concentrated industries. On the other hand, Schumpter (1965) is of the view that since R&D is risky and hence it is funded by the retained profits. Since the profit rates are higher in concentrated industries, R&D activities are more conducive in case of the concentrated industry. Which view is correct is an empirical question, but the common fact is the focus on market structure. The focus on market structure often fails to explain the firm level differences in conduct and ultimately the differences between the performances of the industry and firm. This is because the SCP perspective assumes that firms within an organization are homogenous. The assumption of homogeneity often draws severe criticism from the subsequent studies, which tried to relax this assumption.

Subsequent studies however declined to believe that firms within industries are homogenous and suggested strategic groups and mobility barriers (Caves and Porter, 1977). This approach is though advancement over the traditional approach of Bain (1951, 1956). However, the essence was the same as within a strategic group firms are homogenous and their behaviour is also same. The competition is more between groups rather than within a group.

On the other hand, literature around the resource-based view (RBV) sees it differently as the focus is on the resources of the individual firm (Wernerfelt, 1984). It views behaviour of the firm as path dependent, which means that the behaviour of the firm is an outcome of its past performance. The competitive advantage of some firms within an industry is not because of the industry structure, but due to the firms' internal ability.

To sum up, it is clear that a difference in profitability is a crucial issue to all but the perspective used to explain it differs. The sources of differences are attributed to competitive advantages of a few firms or groups or industry. Another fairly accepted fact is that R&D activity is crucial in bringing competitive advantages. Hence the important question is how R&D decisions are made and where is the locus that is how much industry, firm and group affiliation and their interaction affects decisions on R&D activities. This paper is an attempt in this direction by addressing which effect is crucial in deciding upon R&D activities. The rest of the paper is organized as follows: The second part deals with a brief review of existing work in this domain. The third part focuses on the hypothesis

emerged out of the review of literature. The fourth part spells out the model specification and data and sample used in this study. The fifth part brings the empirical finding of the paper and the sixth part concludes the paper.

2. Review of Literature.

The concept of advantages at the country level dates back to the literature on the early writings on international trade. During the initial period, it was considered that the basis of trade was due to the differences in the natural endowments of the countries. The production possibilities differ based on the natural resources and technical ability of the countries. The basis of trade was comparative advantage of some country in the production of some products. Adam Smith summarized the advantages in terms of absolute cost advantage, which comes through division of labour. Over a period of time, labour gets specialization and is able to do things better. These theories certainly help us in understanding the concept of trade. However, in global economy it has got limited validity in the presence of multinationals, which not only exports their products to different countries but also operate from different countries (Porter, 1990). There may be different explanations for competitiveness at different levels. We have considered it here as the ability of a firm to stay ahead of its competitors. It is difficult for the firms to always remain competitive advantage. The continuity of competitive advantage depends on technical innovation and shifting the production possibility upwards. Regarding the industry level, literature dates back to the work of Mason (1939) and Bain (1951). Their model explains the inter-industry difference in profitability. Entry barrier was considered to be an important determinant of profitability differences. The behaviour of the firms includes research and development activities as a significant contributor in increasing the entry barriers.

Subsequent literature however criticizes the framework proposed by Bain and Mason on the grounds of its one-way relationship, that is, structure affects conduct and finally conduct affects the performance. Also, the Bain and Mason framework has not addressed the intra-industry differences in profitability. Studies such as Caves and Porter (1977), Nagesh (1990), and so on, have tried to introduce mobility barriers and the concept of strategic groups within an industry to explain intra-industry differences in profitability. These studies broadly followed SCP as the framework for analysis.

Contrary to SCP, the resource-based perspective analyzes competitive advantage at the firm level [Lippman and Rumelt (1982), Wernerfelt, (1984), Barney (1986, 1991)]. These studies proposed that competitive advantage emanate from firm specific factors, which the firms inherit over a long time, and are not easy to imitate.

By combining these perspectives one can develop a competing hypothesis about the factors affecting the variations in profitability. In the context of sources of performance difference, Schmalensee (1985) partitioned variance into corporate, market share, and industry effect. This study was a landmark in this direction followed by several other studies [Rumelt (1991); Roquebert *et al* (1996), McGahan and Porter (1997)]. Though the results vary across studies, the common factor is that the firm effect dominates the industry effect in explaining variations in the profitability.

One can also identify four important effects, which possibly explain variations in R&D intensity. The first one is industry effect that is rooted in traditional industrial organization literature. The structure of the industry determines the behaviour of the firms. In addition, the behaviour of firms within an industry are greatly affected by the

government policies such as opening up of competition by removing restrictions, tax benefits to local firms for investing in R&D, and so on. Based on these arguments one can hypothesize that industry effect exists, and can explain the variability of the intensity of R&D. The industry effect captures all possible effects of the industry on R&D intensity.

Hypothesis 1*: Industry effect exists and explains the variation in R&D intensity.*

The second effect is based on the extensions of traditional industrial organization approach that is strategic groups within an industry. It is important because in the emerging economies, business groups play a significant role (Khanna *et al*, 2001). It is known by different names such as *grupos* in Latin America, *chaebol* in South Korea, and so on. The members of these groups are connected though a separate legal entity, but a host of decisions are taken keeping these groups into consideration. Group members generate benefits/costs, which are shared by other members (Khanna *et al*, 2001). One can classify the costs and benefits as internal and external. Internal costs and benefits are purely internal, and include bailing the under performing firms. Examples of internal benefits are internal capital generation, pooling resources together in new ventures, internal flow of information among members, and so on. Our second hypothesis is formed based on these arguments.

Hypothesis 2: *Group affiliation effect exists and it explains the firms R&D behaviour.*

Being a member of a group may not solve all the problems a company or firm faces and it is difficult to assume that groups behave uniformly across different industries. One finds that industries innovate more rapidly than others. For example, in the computer or semiconductor industry, technology changes frequently. On the other hand, in the steel industry, technology changes very slowly. Hence one needs to take this into account. We have taken an interaction of industry and group affiliation to capture this effect.

Hypothesis 3: *There exists the interaction effect between industry and group.*

The fourth effect is based on the resource-based views, which see firms as a collection of inherent capabilities. These capabilities are in terms of resources (tangible and intangible) held by the firm. These resources help in value creation and also resist the duplicative efforts. The latter is particularly important as in the presence of high competition, rivals try to imitate, acquire or try to substitute the resources, which are the sources of competitive advantages (Barney, 1991). Therefore in order to maintain the competitive advantage, the firm's should not only innovate, but also continuously innovate (Porter, 1990). We have taken this logic and hypothesized in the context of a firm's effect on R&D decisions. Continuous investment in R&D activities helps in the process of innovation. It is measured by taking average R&D investment made by the firm. A firm's effect in our study is the average R&D intensity over of the last few years.

Hypothesis 4*: Firm effect exists and it determines variations in R&D intensity.*

To sum up, this study tries to capture where is the locus of competitive advantage is found and by how much. The significance of these effects will reveal the validity of the different perspectives discussed above.

We expect industry effect to be significant in the Indian context because very few industries indulge in R&D activities. Firm effect is though important but in Indian case most of the R&D activities are adaptive in nature, that

is, their dependence on imported technology, Desai (1975). We expect group affiliation to be significant. The interaction of group and industry effects is expected to be significant as industry and group affiliation not only reduces the risk of R&D but also synergies of information flow.

4. Model Specification:

The objective of study is to see the effects of industry, firms, group affiliation and its interaction on R&D decisions. For the analysis both continuous (firm effect) and categorical (industry effect, group affiliation, and interaction) are taken into account. Firm effect is measured as the average R&D intensity of the firm in that industry from 1995 to 2003. For estimation of these effects GLM univariate model has been used within a covariance design. Fixed effect model with type III sum of squares[1] are obtained.

The model is as follows:

$$RD_{i,t} = \alpha_0 + \beta_1 ID_i + \beta_2 GD_i + \beta_3 AvgRD_{i,t0\ldots t-1} + \beta_4 IDGD_i + \varepsilon_i$$

Here, $RD_{i,t}$ represents R&D intensity in the year 't' of ith industry where 'i' tends to 1…29 industries. 't' is the time period i.e. 2003. The variable ID_i is a categorical variable representing 29 industries and it takes value from 1…..29. GD_i represents Group affiliation consisting of seven categories representing top 50 Indian companies, large business houses, other business business houses, foreign business houses, private Indian, private foreign and rest others. Finally,'ε' represents error term.

5. Sample:

The data were collected form Prowess provided by Center for Monitoring Indian Economy (CMIE). It reports two R&D figures, that is R&D on capital account and R&D on current account. We have added the expenditure to both in order to reach an aggregate figure representing the total R&D expenditure of the company. R&D on capital account is the capital expense incurred by a company on research and development. The information is sourced from the particulars required under the Companies (Disclosure of particulars in the report of the Board of Directors) Rules, 1988 and not from the income & expenditure statement of companies. In other words R & D expenditure on capital account is not sourced from the profit and loss account statement. Many times, companies do not disclose revenue expenditure on research and development separately because it is a relatively small amount. As a mandatory requirement, companies are required to disclose this information as part of report of Board of Directors. As part of mandatory requirement, companies are required to show research and development expenditure on revenue as well as capital account this helps in estimating total research and development expenses incurred by a company.

[1] Type III sum of squares calculates the sums of squares of an effect in the design as the sum of squares adjusted for any other effects that do not contain it and orthogonal to any effects that do contain it. This type of sums of squares is often considered useful for an unbiased model with no missing cells.

Those companies where sales figurers are not reported in the balance sheet are dropped form the analysis. In all we have taken 1460 firms in our analysis, which can be taken as a good representation of Indian companies. We used CMIE classification in defining our industries.

6. Empirical Analysis:

The analysis reported in this section is based on the ANCOVA design with fixed effects. The dependent variable is R&D intensity of the current year i.e. 2003. The independent variables are industry category, group affiliation and average R&D intensity as covariate. Industry category and group affiliations are categorical variables. Type III sums of square were obtained using SPSS software. The result of this analysis is mentioned in table-1. To avoid the multicollinearity problem, which may come in, we have used stepwise analysis.

The result shows that ownership is consistently insignificant in explaining the variances in the R&D intensity. This can be interpreted as group effect in explaining firm's R&D intensity is not uniform. On the other hand, industry and ownership interaction is significant in all the models suggesting that group strategies are aligned with the industry factors to decide on the R&D behaviour of the firm. Groups also follow industry into mind in deciding the R&D activities. In high R&D intensive industry, the likelihood of the firms affiliated to different groups investing in R&D activities is more. As drawn from the literature of resource based view (RBV) firm's internal ability also matters a lot in R&D decisions. On the other hand, industry effect is also significant suggesting the traditional industrial organization logic i.e. R&D activities are related to the industry in which firms operate. Table-3 summarizes the average effects of the analysis. It suggests that interaction effect is the most significant effect in explaining the R&D behaviour compared to other effects taken in this study.

Table-1. Test for Industry, Group, Firm and its Interaction effects.

		Model-1	Model-2	Model-3	model-4	Model-5
Corrected model						
	SSQ	0.23	0.006	0.044	0.078	0.199
	F	1.67	1.12	1.43	3.04	1.42
	Eta2	0.171	0.005	0.033	0.058	0.149
Intercept						
	SSQ	0.007	0.016	0.009	0.005	0.009
	F	7.72	17.52	9.78	5.52	10.06
	Eta2	0.006	0.012	0.007	0.004	0.008
Firm						
	SSQ	0.031			0.028	
	F	35.76			1.11	
	Eta2	0.027			0.021	
Ownership						
	SSQ	0.007	0.006	0.005		0.007
	F	1.36	1.12	0.855		1.4
	Eta2	0.006	0.005	0.004		0.006
Industry						
	SSQ	0.042		0.038	0.038	0.046
	F	1.74		1.49	43.53	1.87
	Eta2	0.036		0.029	0.03	0.039

Ownership*industry						
	SSQ	0.147				0.155
	F	1.37				1.41
	Eta2	0.117				0.119
Error		1.11	1.33	1.29	1.26	1.14
Total		1.36	1.36	1.36	1.36	1.36
Corrected total		1.34	1.34	1.34	1.34	1.34
R^2		0.171	0.005	0.033	0.058	0.14

Table-3 Average Effects on R&D

Effects	%
Firm	2.94
Ownership	0.44
Industry	2.94
Ownership x industry	10.81

7. Conclusions.

The study is an attempt to explain the factors helps the firm in deciding its R&D activities in India. The study reviewed the existing frameworks used in Industrial organization and Strategic management literatures. The study identified three factors important in explaining the firm's strategies on R&D activities. These are Industry specific factors, firm specific factors and group factors. The study also includes a fourth dimension which is crucial determinants i.e. interaction of group and industry.

The result shows that Industry effect and firm effect are important but contribute little to the decisions to go for R&D. On the other hand, interaction of industry and group affiliation turned out to be significant and major source, which affects the decisions on R&D. It indicates that group effect is not uniformly distributed but it is industry specific. In other words the firms just do not invest on R&D activities because of group affiliation.

This study is limited to the decisions on R&D expenditure of the company / firm. However there could be other strategies, which might substitute of R&D expenditure such as technology imports, joint collaboration with other companies etc. These strategies also can help the companies to gain reasonable competitive advantage in a market like India. This work can be extended in theses lines to understand the factors affecting the competitive strategies of the company/ firm.

Table: 3 Descriptive Statistics.

Sl.no	Industry	Mean	SD	N
1	Alcohol	0.000004	0.00001	14
2	Alkalies	0.000271	0.0008	8
3	Automobile	0.005342	0.0095	86
4	Auto Ancillary	0.004863	0.0068	27
5	Cement	0.000937	0.0020	29
6	Cosmetics	0.005118	0.0058	12

7	Dyes and pigments	0.005175	0.0076	20
8	Electric machinery	0.003607	0.0116	91
9	Electronics	0.002731	0.0066	124
10	Ferrous Metals	0.000523	0.0017	126
11	Fertilizer	0.000496	0.0011	26
12	Food Products	0.003254	0.0305	129
13	Inorganic chemical	0.003762	0.0128	29
14	Non-electrical	0.007137	0.0091	98
15	Non-ferrous	0.001162	0.0020	24
16	Organic Chemical	0.000556	0.0020	34
17	Other chemical	0.003855	0.0091	29
18	Other non-metallic	0.000835	0.0023	72
19	Paint & varnishes	0.002698	0.0049	9
20	Pesticide	0.004318	0.0035	12
21	Petroleum	0.001408	0.0021	16
22	Pharmaceutical	0.010828	0.0166	85
23	Plastic	0.024249	0.1248	70
24	Polymer	0.002340	0.0034	21
25	Rubber	0.002011	0.0033	11
26	Soaps	0.002589	0.0052	7
27	Textile	0.001497	0.0129	237
28	Tobacco	0.003733	0.0067	5
29	Tyre and tube	0.001936	0.0022	9
	Total	0.004229	0.0303	1460

References:

Arrow, K, '*Economic Welfare and the Allocation of Resources for Invention*' *The Rate and Direction of Inventive Activity*, NBER , Princeton, 1962

Bain, J.S, 'Relation of Profit Rates to Manufacturing Industry Concentration American Manufacturing, 1936-40', *Quarterly Journal of Economics*, Vol. 65, pp. 293- 324. 1951

Bain, J.S, '*Barriers to New Competition'*, Harvard University Press, 1956.

Barney J. 'Firm resources and Sustained Competitive Advantage', *Journal of Management,* vol-17, page 99 – 120. 1991.

Caves, R.E, and M.E. Porter, ' From Entry Barriers to Mobility Barriers: Conjectural Decisions and Contrived Deterrence to New Competition, *The Quarterly Journal of Economics*, Vol-91, No-2, May, page 241-262. 1977.

Desai A.V. 'Research and Development in India,' *Margin,* January, 1975.

Hay, D.A and D.J. Morris , Industrial Economics, *Oxford University Press*, 1991.

Khanna. T & Palepu 'Is Group Affiliation Profitable in Emerging Markets? An Analysis of Diversified Indian Business Groups'. *Journal of Finance, Vol-* 55 no-2, pp 867-891, *2000*

Khanna T and Rivkin J.W, 'Estimating the Performance Effects of Business Groups in Emerging Markets, *Strategic Management Journal*, vol-22, , page 45-74, 2001

Lippmam S, Rumelt RP. Uncertain Imitability: An Analysis of Inter-firm Differences in Efficiency Under Competition. *Bell Journal of Economics*, vol-13, page 418 – 38. 1982

Mason, E.S, , 'Price and Production Policies of Large Scale Enterprises. *American Economic Review Supplement*, Vol. 29, pp. 61-74, 1939.

McGahan AM, Porter ME. How Much Does Industry Matter Really, *Strategic Management Journal* vol-18, page 15 – 30, 1997.

Porter, Michael E., Competitive Advantage of Nations, New York: The Free Press, 1990

Nagesh K, 'Mobility Barriers and Profitability of Multinational and Local Enterprises in Indian Manufacturing', *The Journal of Industrial Economics* Vol-XXXVIII, June, No.4 pp. 449-463, 1990.

Roquebert JA, Phillips RL, Westfall PA. Market versus management: what "drives" profitability. *Strategic Management Journal* vol-17, page 33 – 64, 1996

Rumelt RP, 'How Much Does Industry Matter'. *Journal of Strategic Management vol-12 page 167-185, 1991*.

Schmalensee, R (1985) 'Do Markets Differ Much', *American Economic Review* vol-75, page 341-351.

Schumpeter, J.A, (1965), '*Capitalism, Socialism and Democracy'* London: George Allen and Unwin 1965.

Wernerfelt B. A Resource-Based View of the Firm, Strategic Management Journal, vol-5 page 71-80, 1984.